Improve WRF nocturnal LLJ simulation by incorporating turbulence intermittency effect in PBL parameterizations

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Outline

- Motivation & Objectives
- Case Overview
- Model Improvements
- Experiment Results
- Conclusions and Future Work

Motivation

- **Central Plains NLLJ:**

Important wind resource.
Associated with precipitating systems.

- **Known problems:**

However, NLLJ is under-predicted by NWP models.

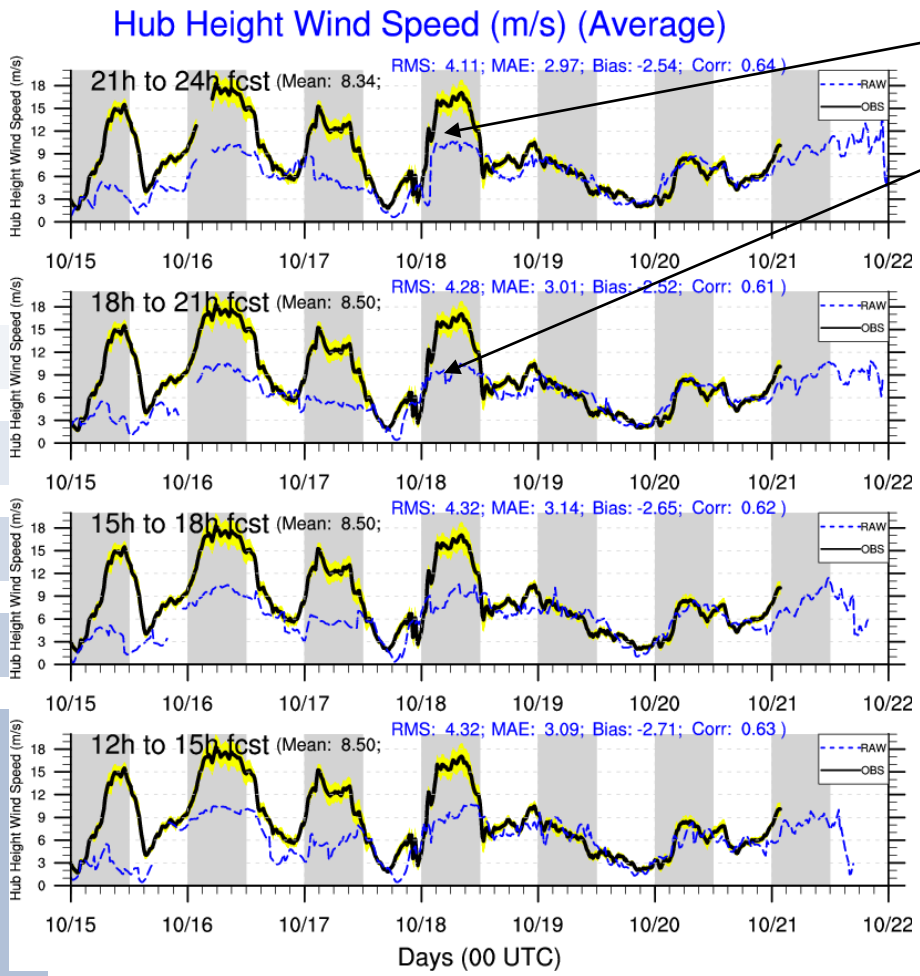
- **Storm et al (2008)** reported WRF under predicted NLLJ.
- An example from the Xcel WRF-RTFDDA wind forecasting system

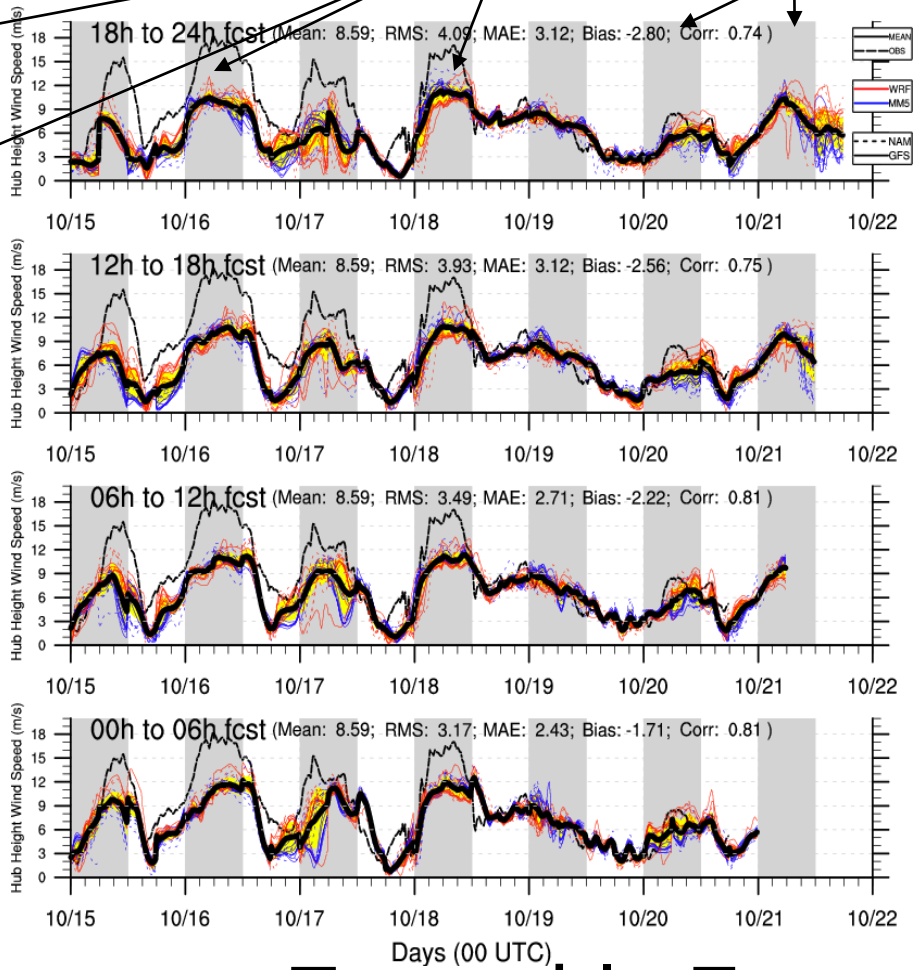
Hub-height Wind Forecast and Obs

NCAR

At a NW TX wind farm (35.2N,102.3W): underpredicted

Shaded: Night Time





Deterministic Forecast

Ensemble Foreca

Objectives

1. LLJ occurs due to several mechanisms*:

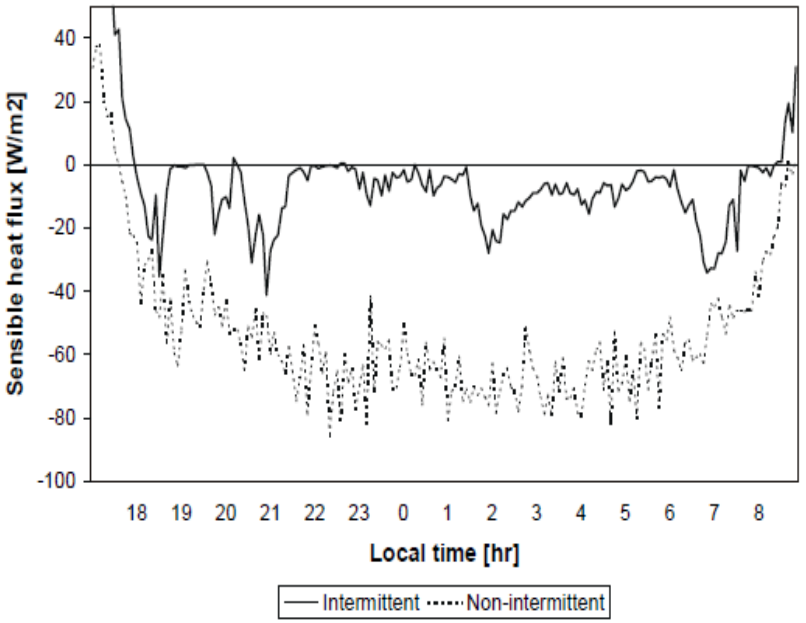
-Inertial oscillation due to diurnal variation in eddy viscosity

-Near surface baroclinicity (e.g., sloping terrain or surface lows).

-Isallobaric forcing due to upper level jet streaks.

2. Turbulence Intermittency has not been considered in stable BL parameterizations

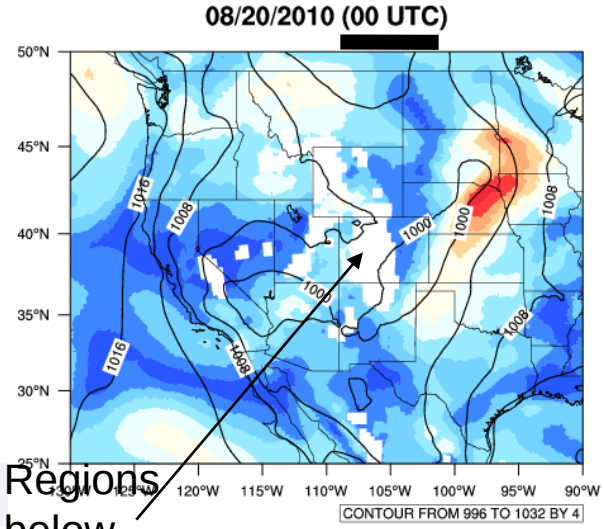
3. In this work, we incorporated turbulence intermittency into WRF stable parameterizations and tested with case studies.

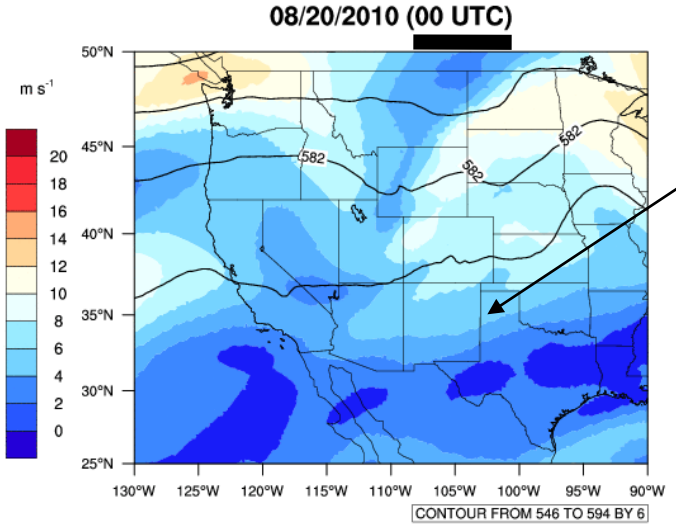


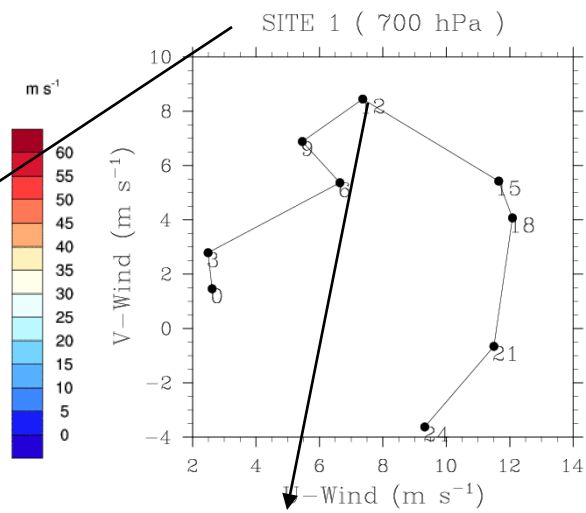
Van de Wiel et al (2002)

*Blackadar (1957), Holton (1967)

Case Overview: 19-20 Aug 2010

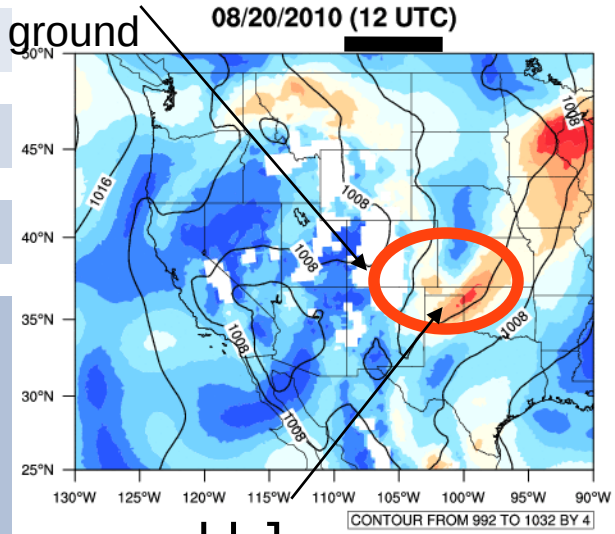




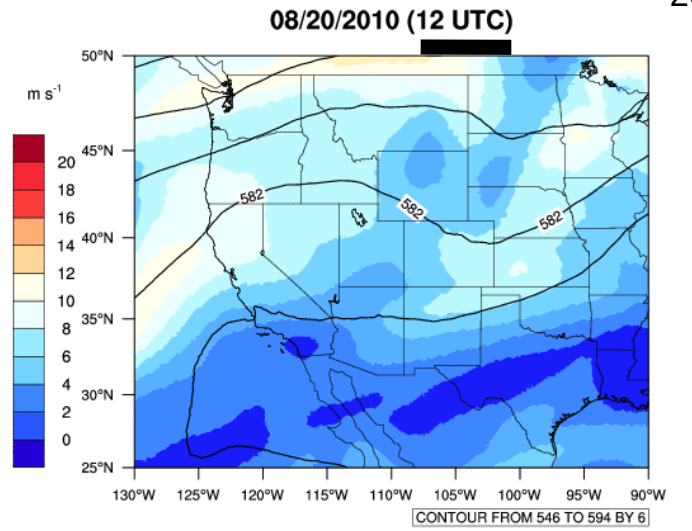


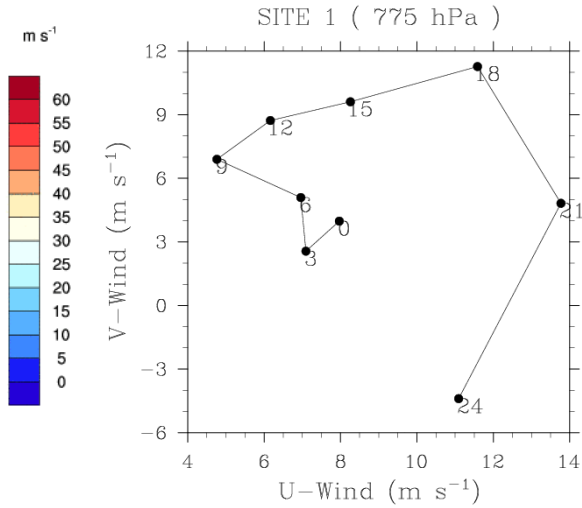
20 Aug /00 UTC or 18 LST

Regions below ground



LLJ



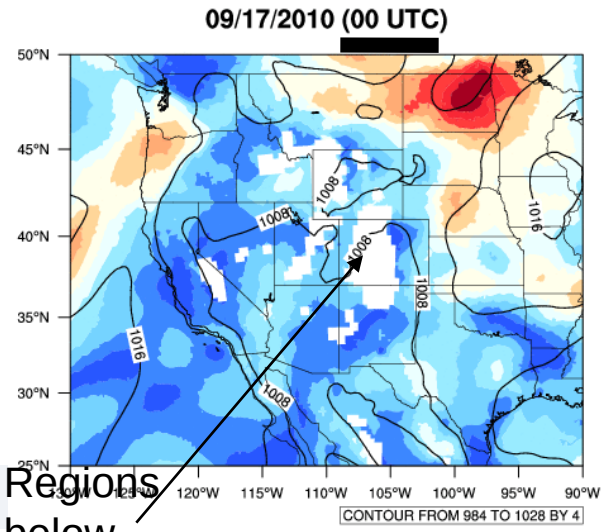


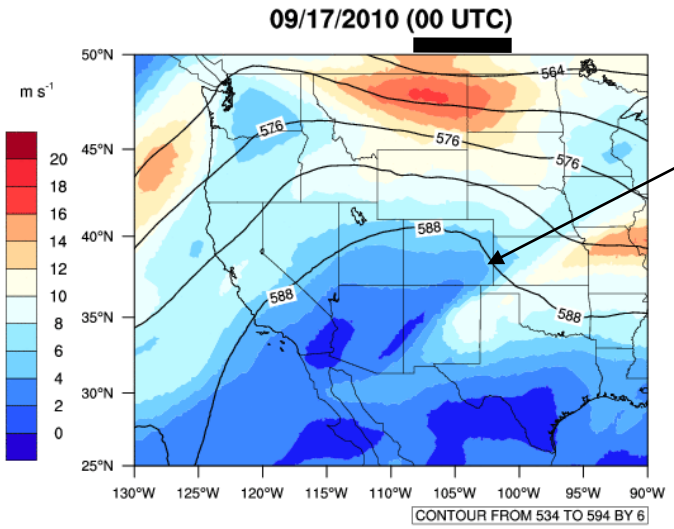
MSLP (hPa) / 775 hPa isotach (m/s)
NARR

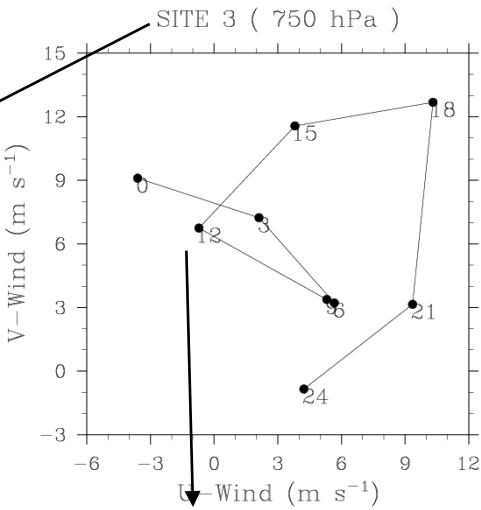
500hPa Geopot. Ht (dam) / 300 hPa isotach (m/s)
NARR

Hodograph

Case Overview: 16-17 Sept 2010

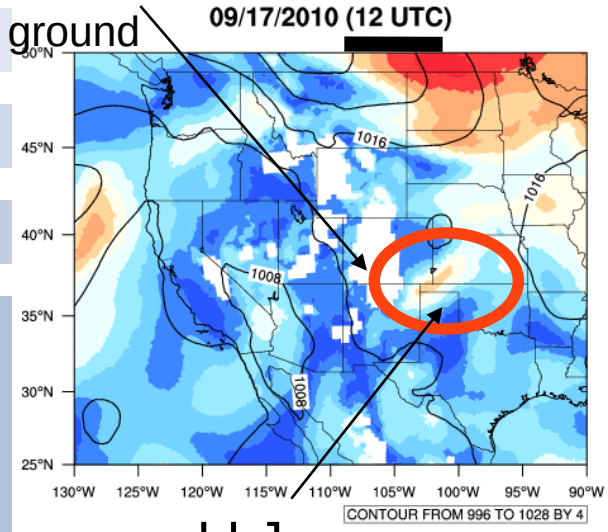




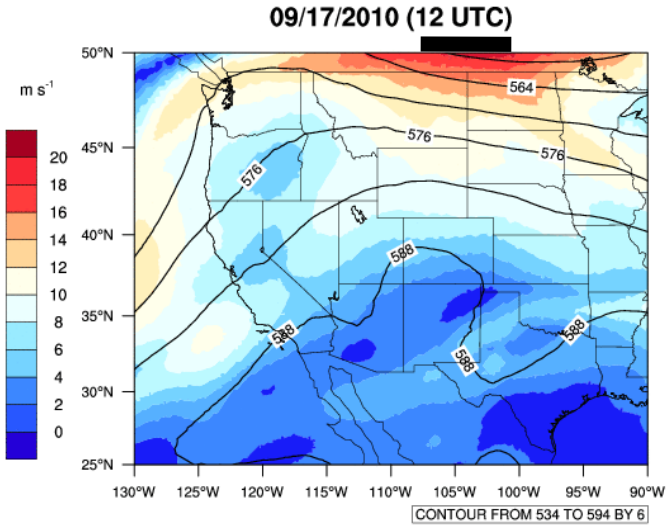


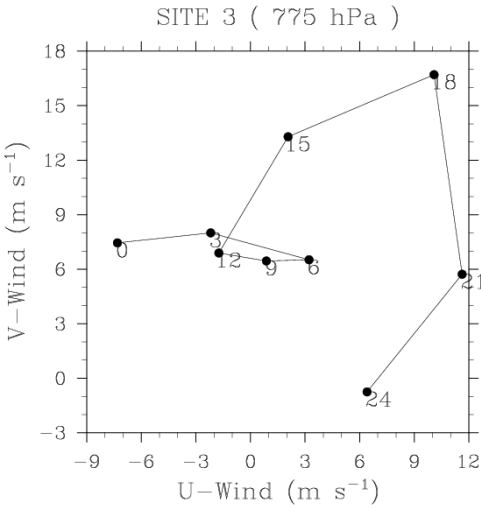
17 Sept /00 UTC or 18 LST

Regions below ground



LLJ





MSLP (hPa) / 775 hPa isotach (m/s)

500hPa Geopot. Ht (dam) / 300 hPa isotach (m/s)

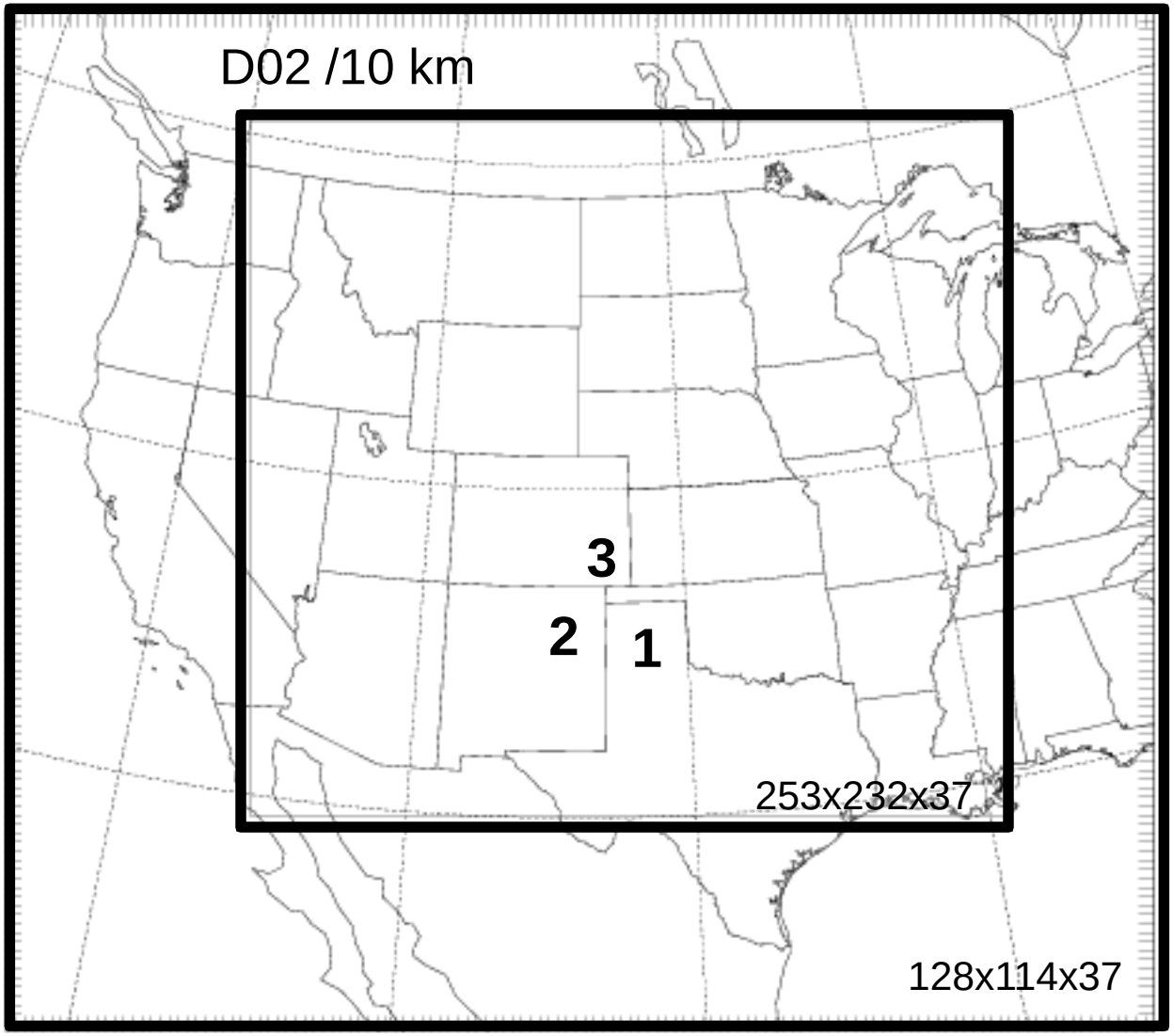
Hodograph

NARR

Summary- Processes

Date	Surface Low	Jet Streaks (300 hPa)	Inertial oscillation	Mechanisms
19-20 Aug	Trough present	Not present	775-700 hPa evident	Inertial osc. & sfc trough
16-17 Sept	Not present	Present	775-750 hPa evident	Isallobaric forcing (?), inertial oscillation.

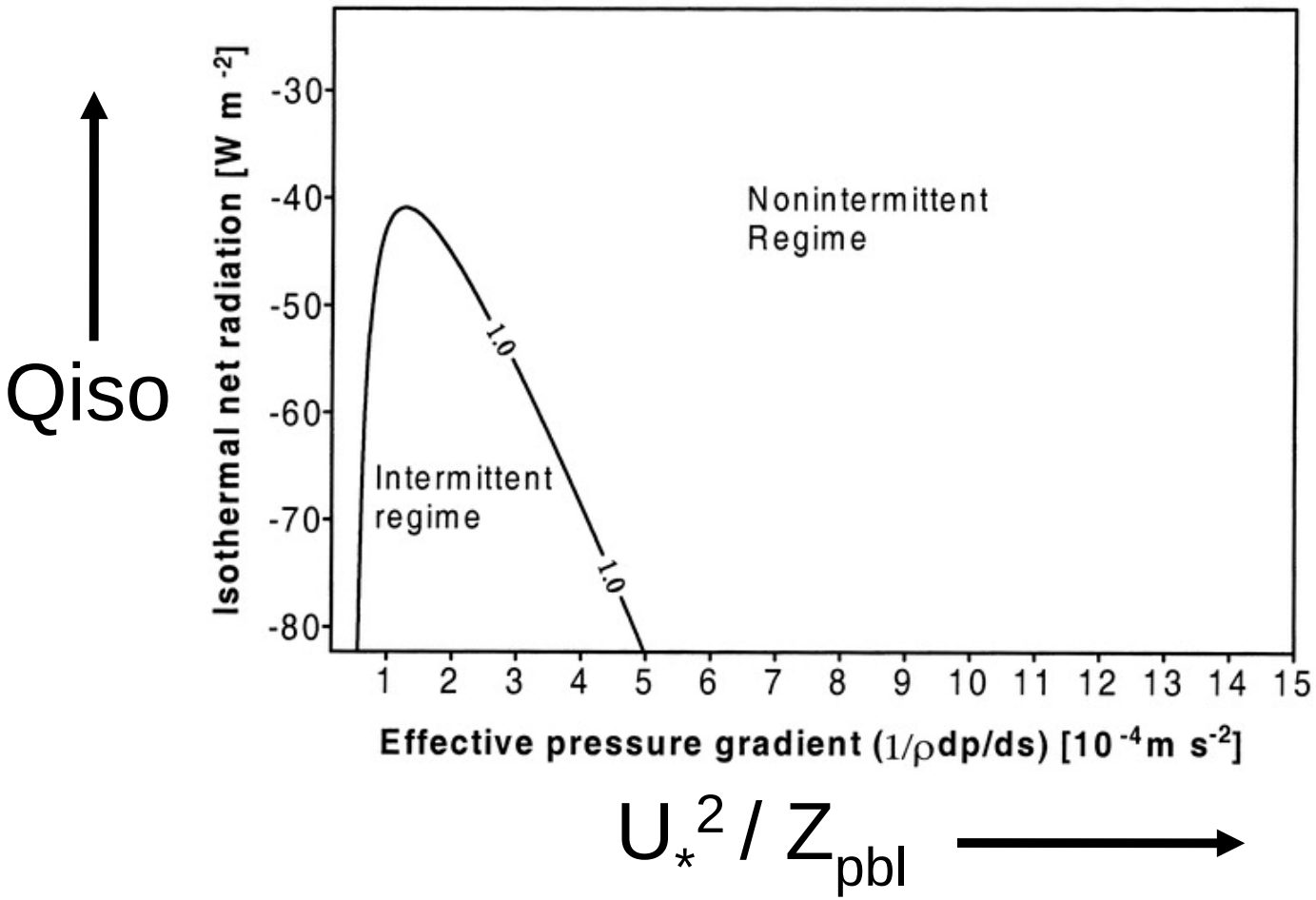
Model Domain



- WRF-ARW V3.2.1
- MYJ / YSU PBL
- IC: GFS Forecasts
- LBC: 3 hourly GFS Forecasts (1X1º)
- 24 h forecasts
- Model initial times:
  19 Aug 2010/12UTC
  16 Sept 2010/12UTC

Scheme Description (1)

Van de Wiel et al (2003) turbulent intermittency criteria



Qiso = $Qnet_{lw} - 4\ \sigma\ T_{ref}^{3}(T_{10m} - T_{sfc})$ where T_{ref} = 285 K

Scheme Description (2)

Criteria:

- $-20\ W\ m^{-2} < Qiso < -85\ W\ m^{-2}$
- $1 < U_*^2 / Z_{pbl} < 9 \times 10^{-4}\ m\ s^{-2}$
- Local Time: 1800 and 0600

Intermittency Factor (IF):

a) $IF = (T-T_i)/T$

$T = \Delta x / V_{10}$ and T_i is time interval over which turbulence is intermittent.

b) T (min/max): Δt /1 h

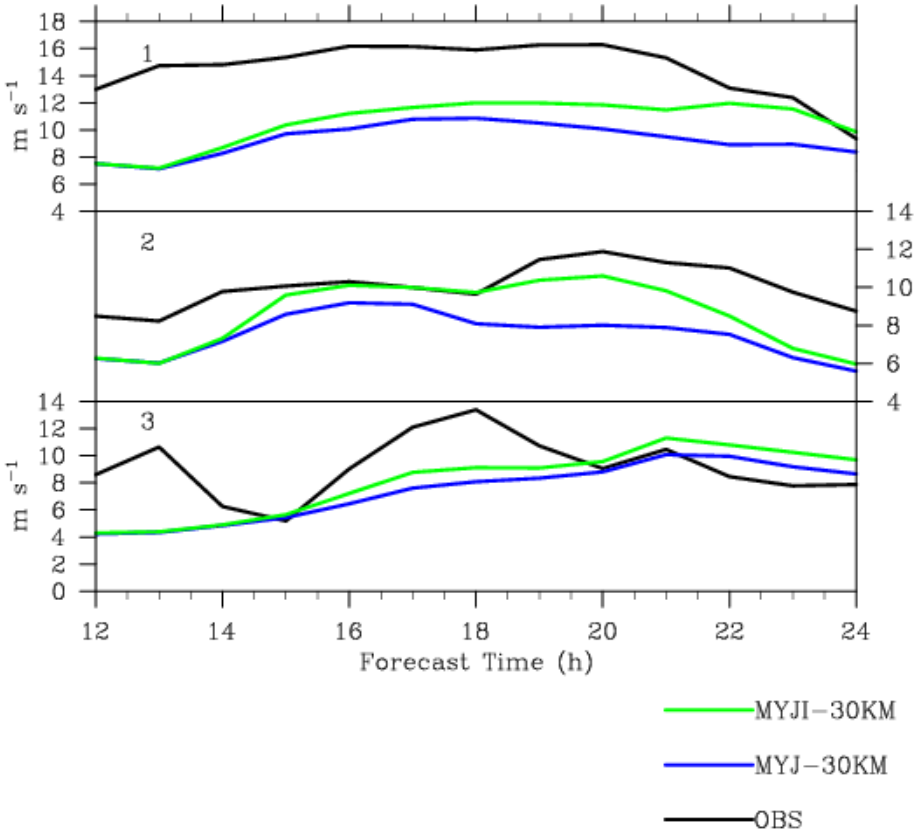
c) PBL tendencies multiplied by IF.

Turbine level wind speed* (Model vs Obs)
30 km run

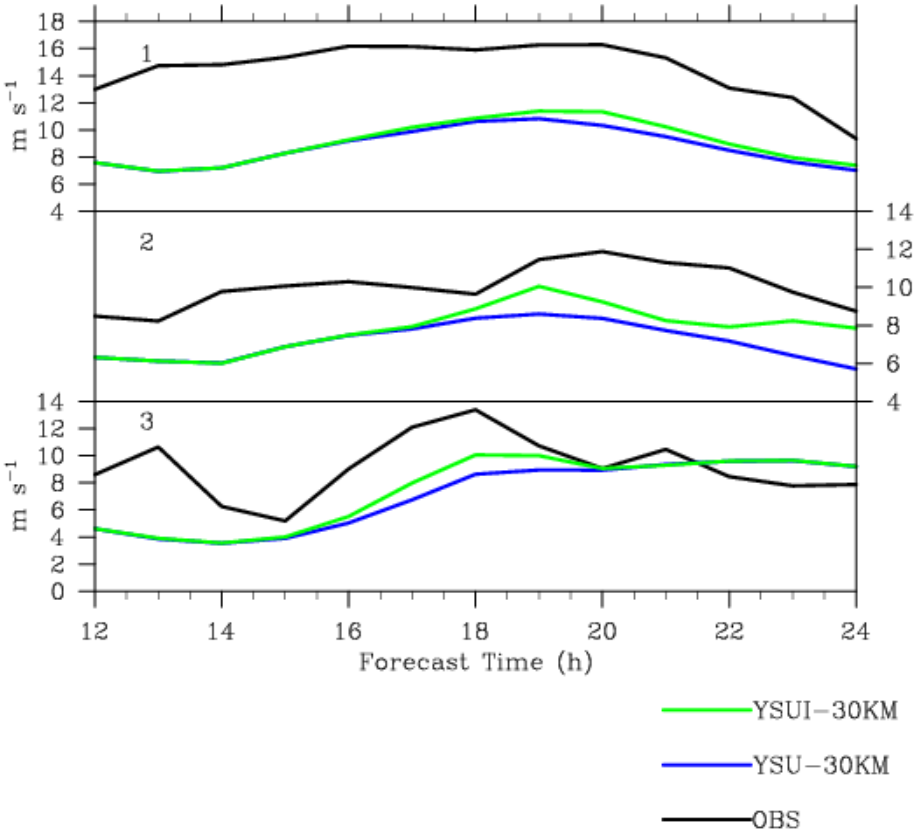
00 – 12 UTC / 18 – 06 LST

20 Aug 2010

MYJ



YSU



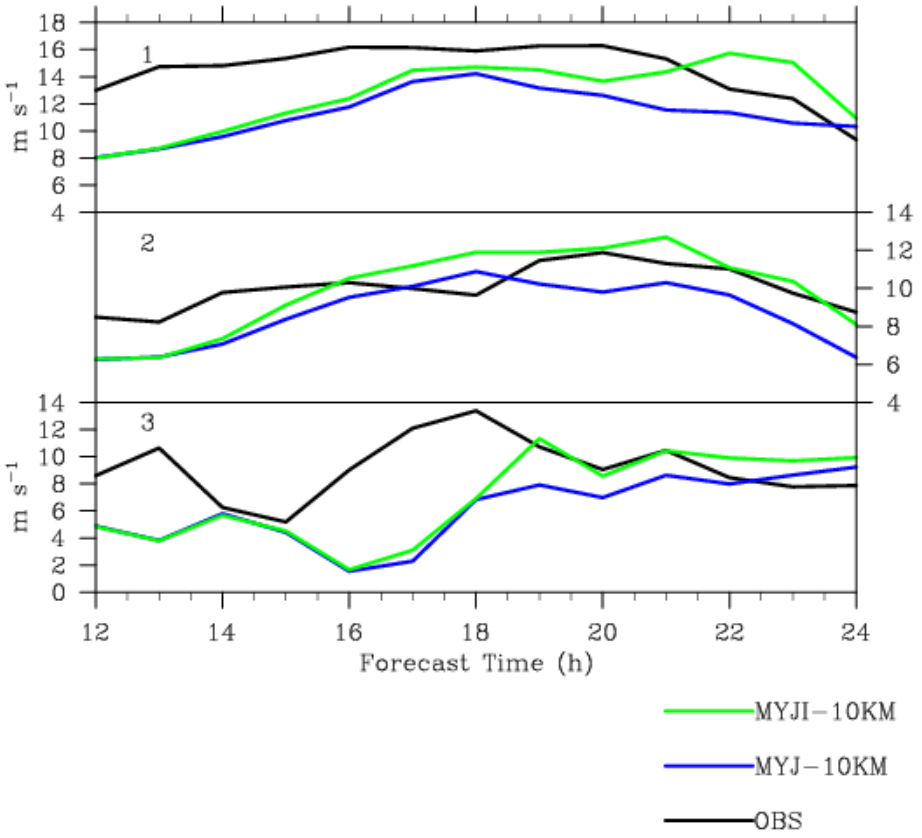
*80 m AGL

Turbine level wind speed* (Model vs Obs)
10 km run

00 – 12 UTC / 18 – 06 LST

20 Aug 2010

MYJ



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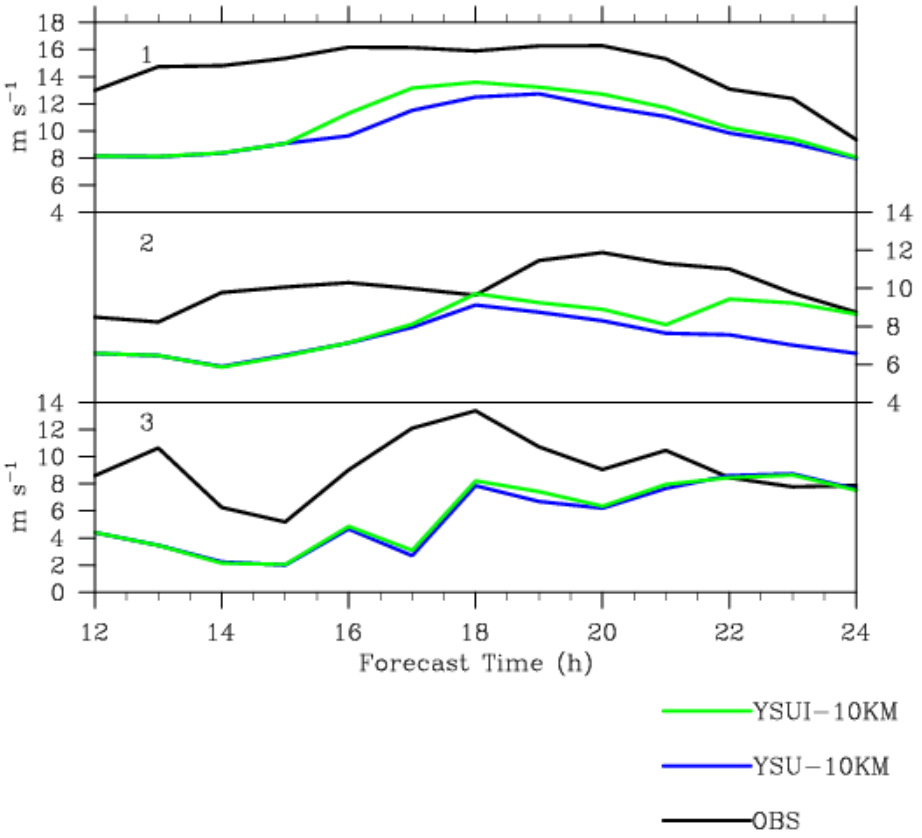

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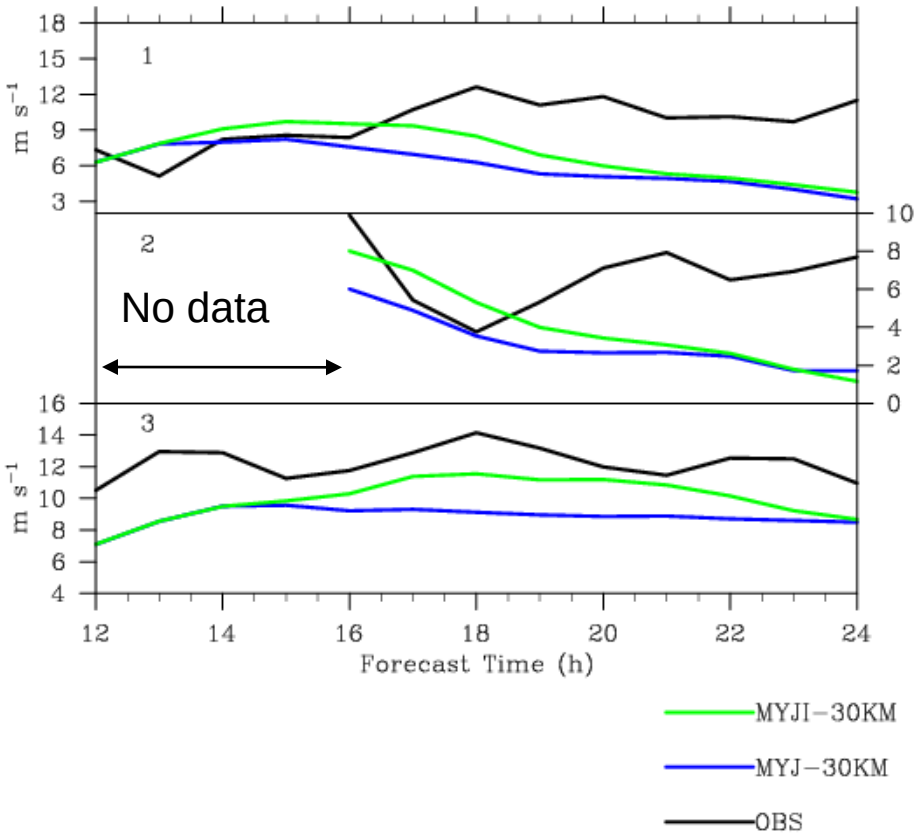

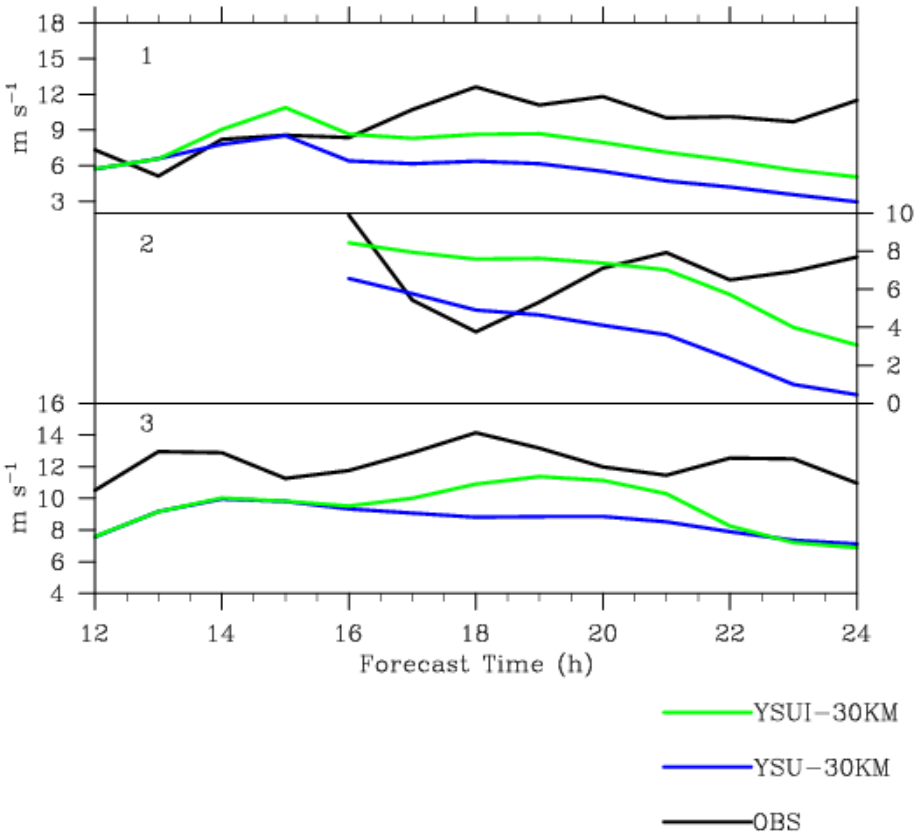

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10 km run

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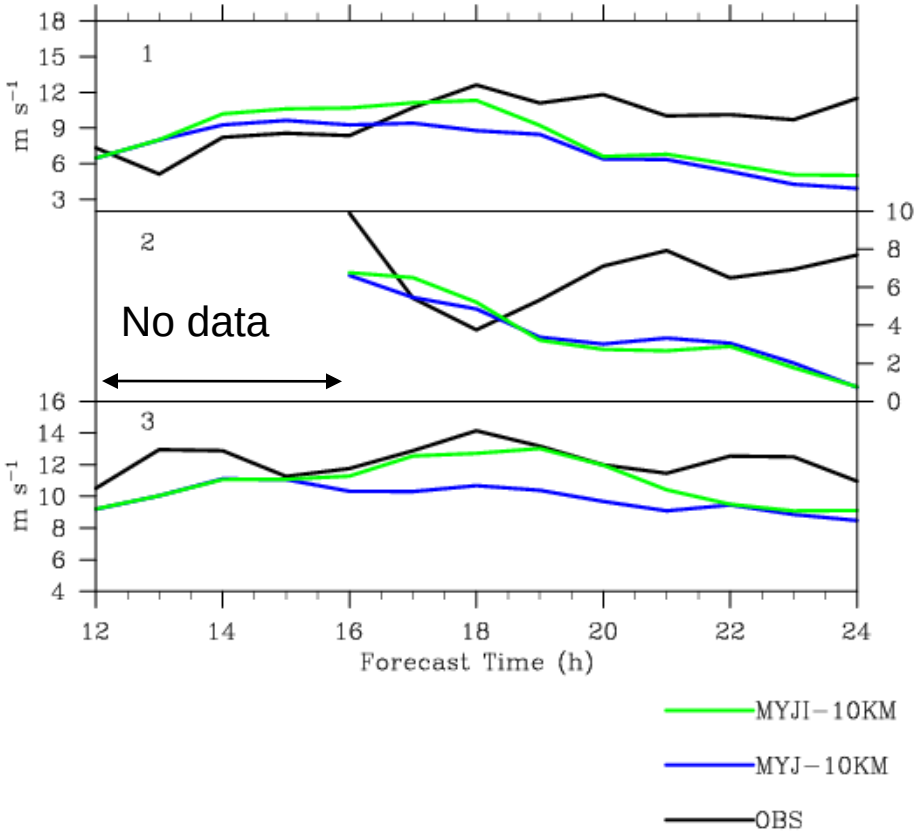
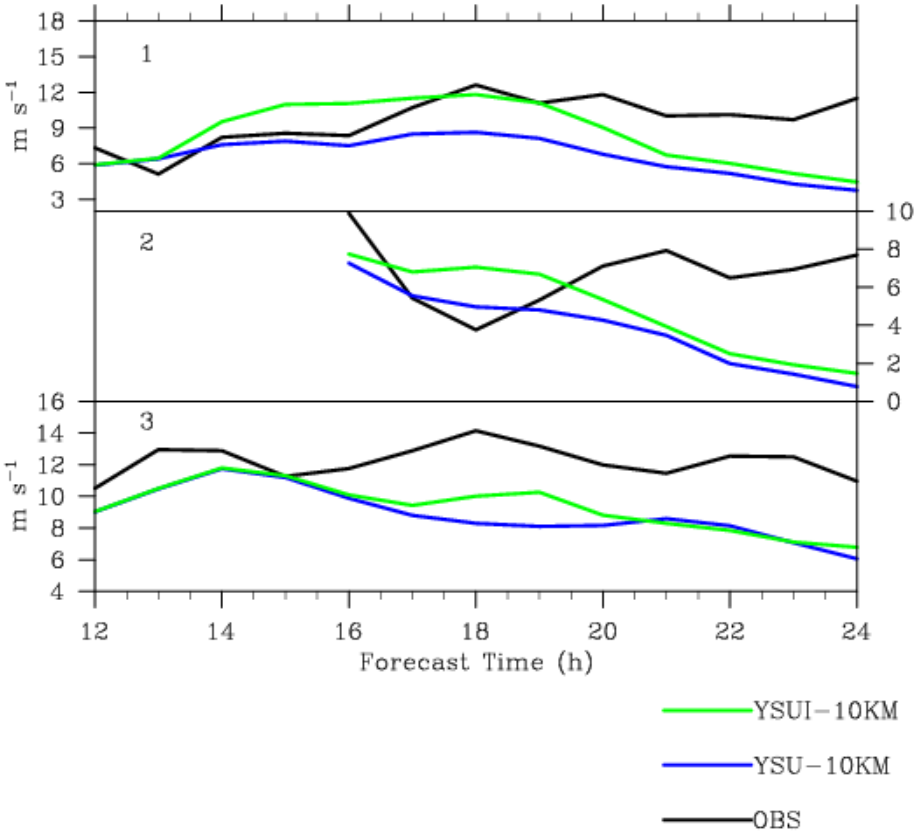




*80 m AGL

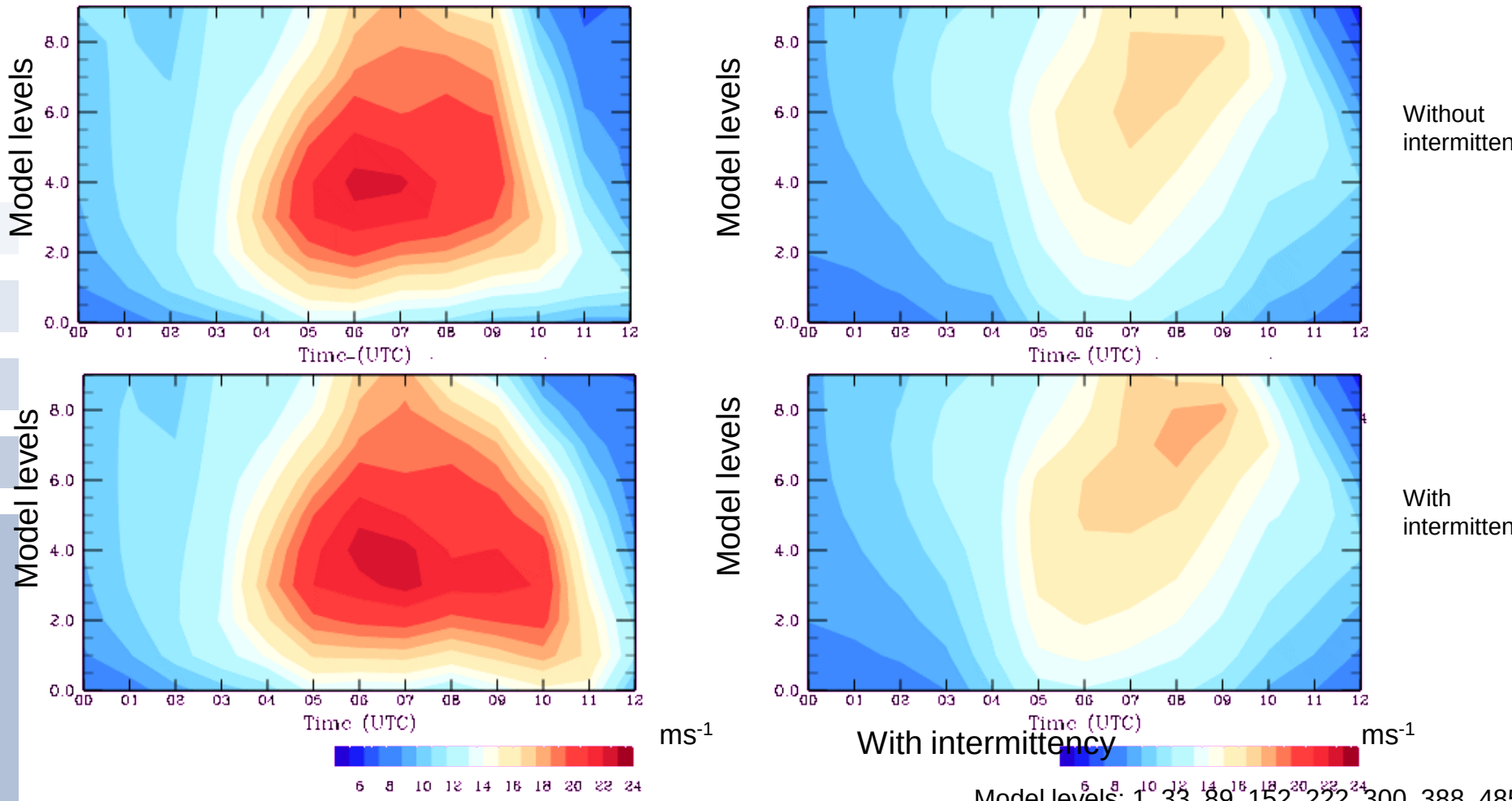
Vertical cross section of wind speed with and without Intermittency 10 km run

00 – 12 UTC / 18 – 06 LST

20 Aug 2010

MYJ

YSU



Model levels: 1, 33, 89, 152, 222, 300, 388, 485

Conclusions

- Van de Wiel et al (2003) criteria for turbulent intermittency positively impacts hub height WRF wind speed forecasts.
- The wind speed increases over 3 wind farm sites.
- Clear improvements evident at 30 and10 km resolution.
- The improvement evident for MYJ and YSU schemes.
- LLJ jet core speeds increase + descends somewhat.

Future Work

- Impact of increased vertical & horizontal resolution
- Extend study using other PBL schemes (MYNN, Q
- Sensitivity experiments (e.g., time series length).